

# FIRE SYSTEM DESIGN GUIDE

## SYSTEM DESIGN

In order to undertake the process of designing a fire system for a building it is necessary to have a sound understanding of the relevant design standards, the legal framework surrounding building safety legislation and a sound working knowledge of product application theory. The importance of consultation with all relevant parties cannot be over stressed, neither can the importance of specialist advice in relevant areas. The following system design process is intended to give a reasonable overview of all the areas of knowledge required for the successful design of a fire alarm system.

It is envisaged that the user will refer to the information contained within the design section to determine the areas where further detailed advice will be required and to give guidance as to where such advice may be contained.

Due to the complex nature of legislation and design standards relating to fire alarm system design, this design guide is not intended to be a comprehensive guide to all aspects of fire alarm design but rather a very useful source of background information to which further application specific detailed information can be added from other sources as required.

The standards referred to in this section relate to the UK and Europe. Although the principles are broadly universal, it is recommended for readers in other countries that they familiarise themselves with specific local requirements from their own standards, only using the British or European standards where these have been accepted by local fire authorities. Information relating to equipment facilities and performance apply to Cooper Lighting and Security equipment and may not necessarily apply to other manufacturers equipment. The reader should carefully check whether such comments relate to equipment from other manufacturers before considering alternative equipment.

## OVERVIEW OF THE DESIGN PROCESS

The following describes a typical fire alarm system design process, after each item a section number is provided which relates to the area within the design guide where further information can be found.

- Understand the reasons for installing the fire alarm system in the specific property (section 1)
- Conduct a risk assessment to help determine requirements (section 2)
- Consult with all interested parties (section 3)
- Decide on the relevant design standard (section 4)
- Establish if third party approval is required - for equipment and /or installation.
- Decide on the type of alarm technology to be used (see pages 16-20)
- Decide on the appropriate protection category and extent of coverage where relevant (section 5)
- Discuss and agree the fire strategy (section 6)
- Plan the zoning of the building (section 6)
- Select and position relevant system components (section 7)
  - Select the appropriate detectors for each area
  - Position the detectors
  - Select suitable callpoints and position at appropriate locations
  - Agree on the means of summoning the fire authority
  - Plan the alarm signalling arrangements (sounders, beacons, pagers etc)

## OVERVIEW OF THE DESIGN PROCESS (cont'd)

- Select a suitable panel (suitably sized and rated with adequate standby autonomy)
- Review the design such as to - minimise the potential for false alarms (section 8)
- Select Contractor
- Ensure suitable wiring of the system (section 9)
- Make suitable arrangements for commissioning (section 10)
- Appoint/Establish responsible person (section 11)
- Make suitable arrangements for ongoing maintenance and monitoring of system performance (section 11)

## BACKGROUND LEGISLATION

The following section contains details of European legislation which relates mainly to legal requirements placed on the manufacturer or importer of equipment. The description is included here to give the user/specifier an understanding of the subject.

### EMC

The EMC directive requires that all electrical and electronic equipment is able to co-exist without interference. There are two basic levels, which relate to the type of environment, industrial and commercial/light industrial. The industrial level allows equipment to emit more electrical noise taking into account the problem of containing electrical noise in large electrical machines. EMC standards are continually evolving as communication equipment becomes more sophisticated and measurement techniques improve.

In principle Fire Alarm equipment must emit low levels of noise but be able to withstand high levels, so that it can be used in all applications. To that end a product family standard, EN50130-4 has been published to cover alarm equipment susceptibility and the commercial/light industrial generic standard is used for emissions.

### LVD

The Low Voltage Directive requires that all electrical equipment connected to low voltage supplies (up to 1000V) must be safe. Various standards are published relating to different types of equipment but the general standard EN60950 is applied to fire detection and alarm equipment.

Most items in commercial fire detection systems are designed to work at Extra Low Voltage (24V) and so the LVD does not apply, the exceptions being fire alarm panels, mains rated relays or interfaces and other items of equipment connected to the mains supply such as door closers, smoke vents etc.

### CPD

The Construction Products Directive relates to building materials and equipment fixed to the structure of the building. One section of the directive relates to Safety In Case Of Fire and mandate 109 requires that all fire detection and alarm equipment is third party certified to the relevant Harmonised European standard. In most cases this will be a part of the EN54 suite of standards, e.g. EN54-2 for control equipment or EN54-5 for heat detectors. Many of these standards are published but are in the process of harmonisation. Once harmonised there will be a transition period before compliance becomes mandatory. Therefore at present third party approval is voluntary but over the next few years it is expected to become mandatory.

### CPD (cont'd)

Third party testing to an EN54 standard is very expensive, this may therefore restrict the level of customisation that can be offered by manufacturers in the future.

### CE MARKING

Currently CE marking is used to indicate that the equipment meets the EMC and LV directives. It will also apply to CPD compliance once mandated standards are in place for the items of equipment in question. CE marking is not retrospective and generally it will be clear as to what directive the marking relates to. The mandated standards will be parts of EN54 for fire alarm and fire detection systems.

### RoHS

The Restriction of Hazardous Substances directive currently does not apply to fire detection and alarm equipment. However it is likely that once alternative materials become available and reliable (particularly in the case of lead solder,) then the scope of the directive will be enlarged to cover current exceptions and to incorporate more materials. The objective of the directive is to require manufacturers to stop using substances that potentially provide some health risk, in electrical and electronic equipment.

## 1.0 WHY HAVE A FIRE ALARM SYSTEM?

The answer to this question depends on the premises in question and the legal requirements. In large high-rise buildings, such systems are essential to warn all occupants that a fire or emergency situation exists and the system is used to control evacuation in an orderly way. Large sites with a retained fire brigade may require the system to call the brigade and direct them to the area of risk. The property may have considerable intrinsic value and the insurers either require a fire detection system or may incentivise its use.

The building may be unoccupied for periods where equipment is still powered and the owner wishes to ensure that if anything goes wrong fire fighters are called to the scene in a timely manner.

Fire alarm systems are often used for other purposes as well as fire detection and alarm, such as bomb alert signalling, monitoring systems for high risk equipment or places, emergency call systems and even class change systems for schools.

Sometimes fire detection and alarm systems are used to compensate for structural fire protection shortcomings or to give special cover for items of high value. Whatever the reason, an automatic fire detection and alarm system generally provides a network of manual callpoints, fire sensors and alarm warning devices over the area covered. It is, in effect, the eyes and mouth of the building to constantly monitor the building and warn if a fire breaks out, or is suspected. In the same way we do if we see flames or smell burning.

### 1.1 Insurance Requirements

Insurance requirements normally relate to the protection of property - rather than life. The objective is therefore to detect fire as early as possible and instigate measures to put the fire out with the minimum amount of damage.

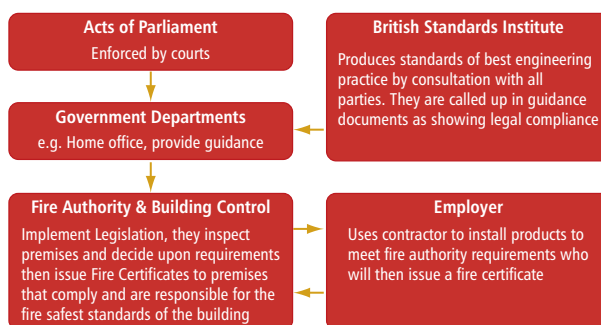
Generally a system designed for property protection will also give protection of life as well but the essential difference is that the requirements for property protection are driven from the insurance company's desires rather than law. BS5839-1 covers both life and property protection, so is equally useful in both cases.

## 1.2 Legal Framework

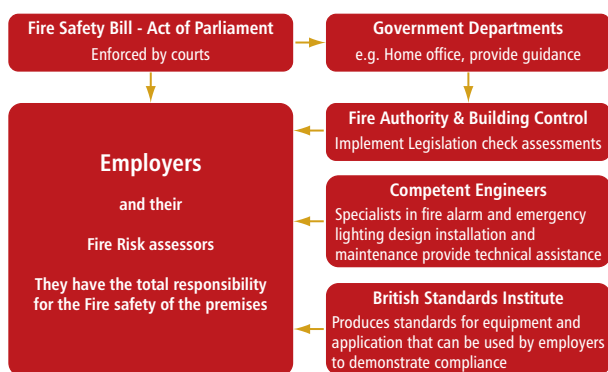
Generally the legal requirement for a fire alarm system relates to the protection of life. Either of those in the building or those in adjacent buildings. The primary objective of life protection is to warn occupants of the risk of fire and get them to a place of safety as quickly as possible.

The UK traditionally had a number of regulations relating to different types of building and has used the fire brigade to act as a local enforcement agency either issuing or withholding fire certificates depending on their view of the level of protection provided. This has now changed and the government has devolved the responsibility onto the building owners - with some exceptions. This means that it will become the building owner (or occupier) who is responsible to ensure that the building is safe for those in and around it. The tool to establish the requirement is 'risk assessment'. The overall legal framework as it previously was and is now are detailed in the charts below.

### FIRE SAFETY LEGISLATION - Previous Situation



### Flowchart of Fire Safety for normal premises since October 2006



If a fire detection or alarm system is required then it is necessary to establish the specification for the system. In the UK BS5839-1 is normally the appropriate standard for commercial and industrial premises. BS5839-6 relates to residential premises and other standards such as HTM 82 for hospitals relate to specific building types.

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## 2.0 RISK ASSESSMENT

The first step in the design process is the risk assessment. It underpins the whole system strategy and therefore could be argued as being the most important stage. Risk assessment is the process of considering each part of a building from the point of view of what fire hazards exist within an area and what would happen in the event of fire or if explosion were to occur. This would normally be done when considering the building from the point of view of general safety. Clearly very small premises only require a first level of fire protection, such as safe construction, clear escape routes and a fire extinguisher. Equally obviously, large hotels will require a fully automatic fire detection and alarm system, multiple sets fire protection equipment and adequate emergency lighting and escape signage. The Risk Assessment process is to help building owners of buildings between these two extremes make adequate and appropriate provision.

Building owners or operators will often want to employ the services of a professional risk assessor to ensure that the building is considered impartially and in adequate detail. However there are checklists and technical advice available so that the task can be done 'in-house'. The Government web site for communities and local government provides useful guidance on the subject ([www.communities.gov.uk](http://www.communities.gov.uk)). It is recommended that risk assessors should be fully familiar with the requirements of the latest edition of BS5839:1 and if in doubt consult a suitably qualified specialist.

## 3.0 CONSULT WITH ALL INTERESTED PARTIES

BS5839 stresses the need to consult with all interested parties before embarking on a detailed design. As a minimum the following need to consult to ensure that the fire detection and alarm system meets the requirements of all concerned.

- The authority responsible for enforcing health and safety legislation
- The property insurer
- The building user
- The proposed installer
- Fire engineering specialists (where appropriate)

## 4.0 RELEVANT STANDARDS

Standards are produced for equipment and the application of equipment, they are generally produced or endorsed by BSI. They represent recognised best practice either for the design, manufacture or application of a particular product or product range.

Often these standards are called up within guidance documents for pieces of legislation and since they represent best current practice, can be generally be used by employers to demonstrate that equipment they have installed is adequate and appropriate. The following standards relate to the UK and Europe. There are other standards that relate to specific applications (such as hospitals or data processing installations) and other countries will have their own standards covering the same area as those listed.

### 4.1 BS5839

The BS5839 suite of standards relate to specific areas of application for fire detection and alarm equipment. Specifically part 1 relates to public premises and part 6 relates to residential premises.

#### 4.1 BS5839 (cont'd)

BS5839-1 is a comprehensive code of practice for fire detection

and alarm systems, the requirements relate to both life and property protection and the standard includes much advice and comment which is very useful in informing the building owner or system specifier of the background to the requirements. The standard has been developed through input from the whole fire detection industry over a period of 30 years and is the distillation of expert opinion and practical advice. The application notes that follow relate to the requirements of BS5839:1 2002.

### 4.2 BS5588

The parts of BS5588 form the technical element of the building regulations for England and Wales, they should be consulted to establish the detailed requirements for the building in question. BS5588 is mainly concerned with the structure and design of the building but also contains some requirements for fire detection and alarm systems. The requirements of BS5588 are incorporated within the building regulations giving it mandatory legal status.

### 4.3 BS7273, BS EN 60079-14, BS EN 50281-1-2

The parts of BS7273 are codes of practice for different types of fire protection systems. Generally this is considered separately to fire alarm systems but there may be occasions where a trade off can be made between the two systems, or where the two systems interact and must be interfaced.

BS EN 60079-14 and 50281-1-2 cover areas where there may be risk of explosive gas/vapour or dust respectively, reference to them may be required in certain buildings or where there is a change of use.

### 4.4 EN54

The EN54 suite of standards relates to the design and performance of items of equipment that make up a fire detection and alarm system. Each part relates to a different piece of equipment, for example part 3 relates to alarm devices, part 11 to call points, part 4 to power supplies etc.

Some parts of the standards have options with requirements. These relate to specific features that are required in certain applications but not all. For example all control and indicating equipment must be able to detect fire (with the help of appropriate input devices), must monitor certain functions (such as cables for open and short circuit faults) and must have a disablement facility so that functions or areas of cover can be switched off for maintenance or similar activities. However it is optional to have a test facility or delays to outputs, but if such features are either provided or required in the application (e.g. to allow a local search for fire prior to calling the brigade) then those facilities must meet specified criteria.

It is therefore necessary when specifying compliance to EN54 that the relevant part is identified and that the application standard (such as BS5839-1) is consulted to identify specific options. For example, the UK fire brigade almost always will require zonal light emitting indicators to be incorporated in control equipment to show the extent of the fire event at a glance; this is an option in EN54-2 and many countries in Europe do not require such displays.

### 4.5 BS7671

BS7671 was previously known as the IEE wiring regulations. The standard is called up in BS5839-1 and covers the installation of the system.

## 5.0 SELECTION OF COVER

BS5839-1 lists eight categories of cover, depending on what is required. The category system is a simple short hand method of informing all parties of the objective of the system.

### 5.1 Life Safety

- M - Category M systems are manual systems and rely on the occupants of the building discovering the fire and acting to warn others by operating the system. Such systems form the basic requirement for places of employment with no sleeping risk. **Manual cover should be included in all Life Safety systems except L5 systems where it may or may not be provided.** In addition to manual means of triggering an alarm, L category systems will also normally have an element of coverage using automatic fire detection such as smoke or heat detectors. The precise classification depends on the nature of the area(s) provided with automatic protection
- L5 - Category 5 systems are the 'custom' category and relate to some special requirement that cannot be covered by any other category. Where such systems are specified careful reference must be made to the objective of the cover.
- L4 - Category 4 systems cover escape routes and circulation areas only. Detectors might be sited in other areas of the building, but the objective is to protect the escape route.
- L3 - Category 3 systems provide more extensive cover than category 4. The objective is to warn the occupants of the building early enough to ensure that all are able to exit the building before escape routes become impassable.
- L2 - Category 2 systems relate to automatic fire protection in defined areas of the building as well as satisfying the requirements of category 3. The wider cover would relate to parts of the building considered to have a high level of risk.
- L1 - With category 1 systems, the whole of a building is covered apart from minor exceptions.

### 5.2 Property Protection

- P2 - Category 2 systems provide fire detection in specified parts of the building where there is either high risk or where business disruption must be minimised.
- P1 - The system is installed throughout the building - the objective being to call the fire brigade as early as possible to ensure that any damage caused by fire is minimised. Small low risk areas can be excepted, such as toilets and cupboards less than 1m<sup>2</sup>.

## 6.0 REVIEW OF THE BUILDING

Before looking at the details of the alarm system it is necessary to understand some of the concepts that are used to assist the system designer. Buildings are divided up into sections in three ways as far as fire safety engineering is concerned; fire compartments, detection zones and alarm zones.

### 6.1 Fire Compartments

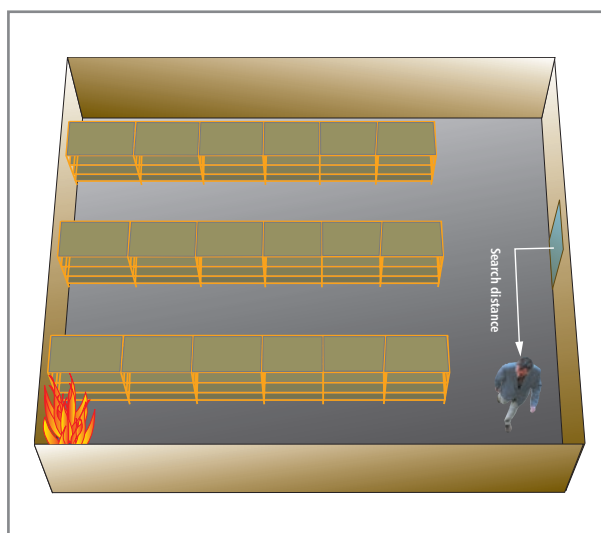
A fire compartment is a part of a building that is separated from the rest of the building by a fire resistant structure so as to limit the spread of fire within the building. The requirements for designing a building and hence its fire compartments, are defined in building regulations and is outside the scope of this document. It is necessary, however, for the designer of a fire detection and alarm system to be familiar with the design of the building, in particular the position and extent of its fire compartments.

### 6.2 Detection Zones

Fire detection zones are essentially a convenient way of dividing up a building to assist in quickly locating the position of a fire. The zone boundaries are not physical features of the building, although it is normal to make the zone boundary coincide with walls, floors and specifically fire compartments. The size and position of the detection zones will therefore tend to be dependant on the shape of the buildings, but will also depend on what the building is used for and to some extent the number of people the building is expected to contain at any one time.

BS 5839-1 has some specific recommendations with respect to detection zones:

- Zones should be restricted to single floors, except where the total floor area of a building is less than 300m<sup>2</sup>
- Voids above or below the floor area of a room may be included in the same zone as the room so long as they are both in the same fire compartment
- Zones should not be larger than 2000m<sup>2</sup> except for manual systems in single storey open plan buildings, such as a warehouse, where up to 10000m<sup>2</sup> is allowed
- Fire detectors in an enclosed stairwell, lift shaft or the like should be considered as a separate zone
- The search distance within a zone should be less than 60m (all possible entrance points must be considered). This can be relaxed when using addressable systems if the information provided at the control and indicating equipment would allow fire fighters, unfamiliar with the building, to proceed directly to the location of the fire. The search distance only relates to the distance from entering a zone to being able to determine the location of the fire, it is not necessary to travel to the fire
- Zones should not cross fire compartments, a fire compartment can contain several zones but a zone should not contain more than one fire compartment



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## 6.3 Alarm Zones

Alarm zones are only needed in buildings where operation of the alarms needs to be different in certain parts of the buildings. If the only requirement is to activate all the alarm sounders to provide a single common evacuate signal once a fire is detected, then alarm zones are not needed, the whole building is one alarm zone.

For more complex buildings where it is necessary to operate alarm devices differently in parts of the building, then the building should be divided into alarm zones such that all of the alarm devices in one alarm zone operate in the same way.

BS5839-1 contains some recommendations for alarm zones:

- The boundaries of all alarm zones should comprise fire-resisting construction
- Signal overlap between alarm zones should not cause confusion
- The same alarm and alert signals should be used throughout a building
- A detection zone must not contain multiple alarm zones, alarm and detection zone boundaries should coincide. An alarm zone may contain multiple detection zones

## 7.0 SELECTION OF EQUIPMENT

### 7.1 Component Compatibility

Because most conventional systems operate in a similar manner, there can be a temptation to mix and match detectors, panels and sounders from different suppliers. Cooper Lighting and Security strongly recommend that all components be sourced from a single supplier to ensure that they are fully compatible with each other.

Minor incompatibilities between components may not be immediately obvious but could cause system malfunction under particular conditions.

Section 11.1 of BS5839 part 1:2002 makes specific mention of the need to confirm that all system components are fully compatible with each other.

Note also that section 12.2.2 of BS5839 part 1:2002 requires that removal of any or all detectors from a circuit should not affect the operation of any manual callpoint. With Cooper Lighting and Security conventional systems, this functionality is inherently provided by the design of the detector base, however with other systems this requirement may require the purchase of additional components or place limitations on the wiring order of detectors and callpoints. Other countries may require that this requirement is met by the use of separate zones (e.g. France).

### 7.2 Repeater Panels

Repeater panels are available for most systems and are required where the fire brigade may enter a building from more than one entrance, where security staff are located away from the main panel or where operational staff need the system information in more than one location, for example in hospital wards.

All control panels including most repeaters, require two power supplies. The back up supply is built into the panel and is provided by sealed lead acid batteries, but a secure mains supply is required for the primary power source. Fuses/isolation switches should be clearly marked to ensure that the fire alarm system is not inadvertently powered down.

### 7.3 Selection of Suitable Equipment Autonomy

Standby time for life safety systems is normally 24 hrs. For property protection this may need to be increased to up to 72hrs where the building is unoccupied over weekends.

Conventional panels and most repeater panels generally have batteries, which are sized to provide a defined level of standby autonomy based on a fully loaded system. For analogue systems, batteries are typically custom sized to suit the required configuration, because the amount and type of connected equipment can vary considerably.

### 7.4 Selection of Appropriate Automatic Detectors

Cooper Lighting and Security provide a range of automatic fire detectors to suit most general risks. Smoke detectors give the earliest warning of fire, typically responding to a fire 1/10th of the size as that required to operate a heat detector.

Optical smoke detectors are suitable for most applications giving the fastest response to slow burning fires - the most common start to fire events. Ionisation detectors were the first type of detector to be commercially developed and are also a popular choice. They have superior response to fast burning fires but an inferior response to slow smouldering fires, which are typical with modern construction materials. Ionisation detectors are also less acceptable from an environmental point of view due to the radioactive material that they contain. There is increasing restriction on the transportation and disposal of ionisation detectors so it is recommended that alternative types are used where possible.

BS5839 section 21.1.8 (d) recommends the use of optical detectors to provide coverage for escape routes due to their superior ability to detect optically dense smoke that would easily obstruct the use of escape routes.

Opto-heat detectors have been developed to mimic the response of ionisation detectors to fast burning clean fires yet maintain the advantage of photoelectric detectors when detecting smouldering fires and allow a higher alarm threshold within the EN54-7 specification under normal conditions thus providing a greater rejection of false alarms.

Heat detectors should be used in environments where the ambient conditions might cause false alarms if smoke detection were to be used, for example where there is a high level of dust, fumes, steam or smoke under normal conditions.

There are three available types of conventional heat detector, a fixed high temperature heat detector which has a nominal trigger temperature of 92°C, a medium fixed temperature heat detector with a nominal trigger threshold of 77°C and a rate of rise heat detector which responds to the rate of change in temperature rather than at a specific temperature. Rate of rise detectors also have a fixed temperature backstop to ensure that even very slow increases in temperature will eventually raise an alarm if the increase continues for a sufficiently long period.

The rate of rise type is the most sensitive type of heat detector, particularly when used in areas where the ambient temperature can reach low levels and therefore create a large difference between the ambient temperature and the trigger temperature of a fixed temperature detector.

#### 7.4 Selection of Appropriate Automatic Detectors (cont'd)

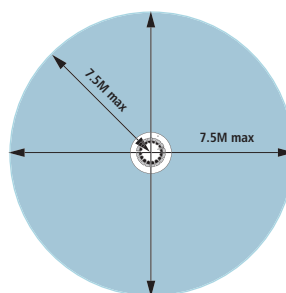
In order to avoid false alarms rate of rise detectors should not be used in areas subject to frequent temperature swings, such as in kitchens, boiler rooms and warehouses with large doors to open air. BS5839-1 recommends that the static response temperature of a heat detector should be a minimum of 29°C above the maximum ambient temperature likely to be experienced for long periods of time and 4°C above the maximum temperature likely to be experienced for short periods of time.

Each type of conventional heat detector is manufactured to have specific characteristics, which cannot be altered. Because analogue systems are more sophisticated, only a single analogue heat detector is produced, the characteristic of which is programmable to suit the relevant application requirements at the time of commissioning and can be altered later if required.

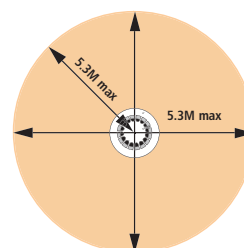
Heat detectors must be mounted closer together than smoke detectors, so whilst the mounting bases are compatible for all types, care should be taken to ensure that the spacing between detectors is appropriate for the detector type fitted. With analogue systems it is possible for the photo thermal detector to act as a thermally enhanced smoke detector during certain times and as a pure heat detector at other times. If this mode of operation is envisaged then spacings must be those appropriate for heat detectors.

#### 7.5 Positioning of Smoke and Heat Detectors

All smoke detectors have similar spacing requirements, heat detectors also all have similar spacing requirements although these are different to smoke detectors. According to BS5839 for general areas the spacing between any point in a protected area and the detector nearest to that point should not exceed 7.5m for a smoke detector and 5.3m for a heat detector.

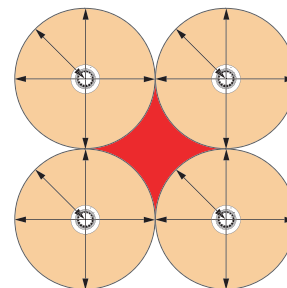
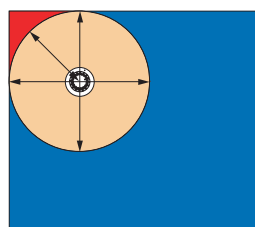


Area of coverage for  
a smoke detector



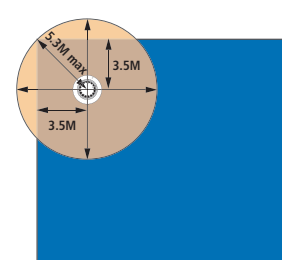
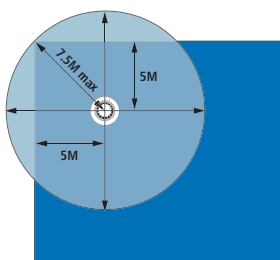
Area of coverage for  
a heat detector

The above are the maximum areas that can be covered by an individual detector. In order to ensure that coverage is provided into the corners of rooms and to ensure that there is no gap at the junction point of multiple detectors, spacings have to be reduced.



= Missed coverage in the corners of rooms and intersections

To ensure complete coverage for square layouts, spacings between detectors and walls should be reduced to 5m for a smoke detector and 3.5m for a heat detector.

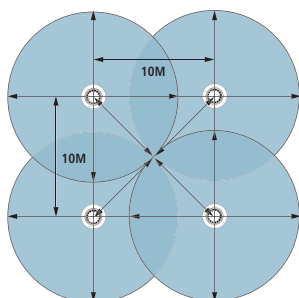




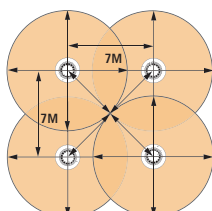
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## 7.5 Positioning of Smoke and Heat Detectors (cont'd)

To ensure complete coverage, spacings between detectors should be reduced to 10.0m between smoke detectors and 7.0m between heat detectors.

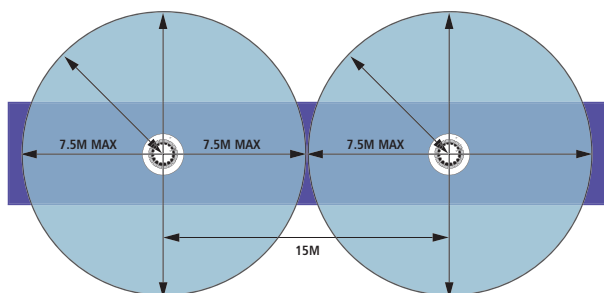


Spacings between smoke detectors



Spacings between heat detectors

For corridors less than 2m wide only the centre line need be considered therefore it is not necessary to reduce detector spacings in order to provide complete coverage. Therefore for smoke detectors spacing becomes 7.5m from a wall and 15.0m between detectors. For heat detectors the spacing becomes 5.3m to a wall and 10.6m between detectors.



Corridor spacing for smoke detectors

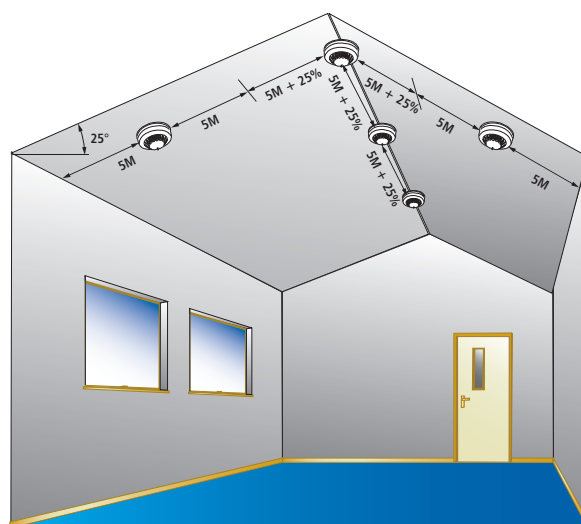
The above data is based on flat level ceilings; for pitched ceilings or ceilings with a non-flat surface, spacings will alter. For pitched ceilings use the data below, for other ceiling types refer to BS5839 for comprehensive guidance. Where detectors must be mounted onto a pitched ceiling, a detector should be mounted near to the apex but spacing can be increased by 1% for each 1° of slope up to 25%. 'Near' is defined as within 600mm for smoke detectors and within 150mm for heat detectors.

## 7.6 Mounting Heights of Detectors

Under all normal circumstances point type fire detectors should be mounted on the ceiling - this ensures that the height restrictions are met together with the following table.

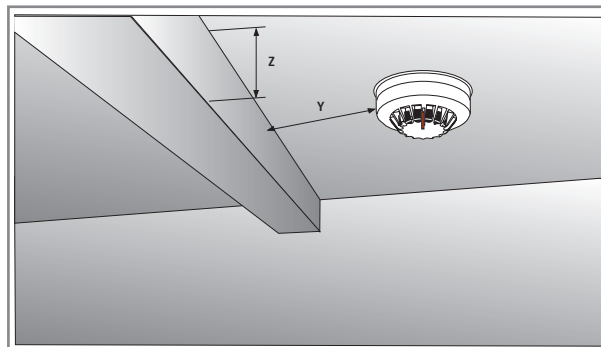
|                                | Ceiling Heights (m) |                   |
|--------------------------------|---------------------|-------------------|
|                                | General Limits      | Rapid Attendance* |
| Heat detectors - class A1      | 9                   | 13.5              |
| Heat detectors - other classes | 7.5                 | 12                |
| Point type smoke detectors     | 10.5                | 15                |
| Optical beam smoke detectors   | 25                  | 40                |

\* Rapid attendance values can be used in type P systems providing fire brigade response time is less than 5 minutes



### 7.7 Beams and Other Similar Ceiling Obstructions

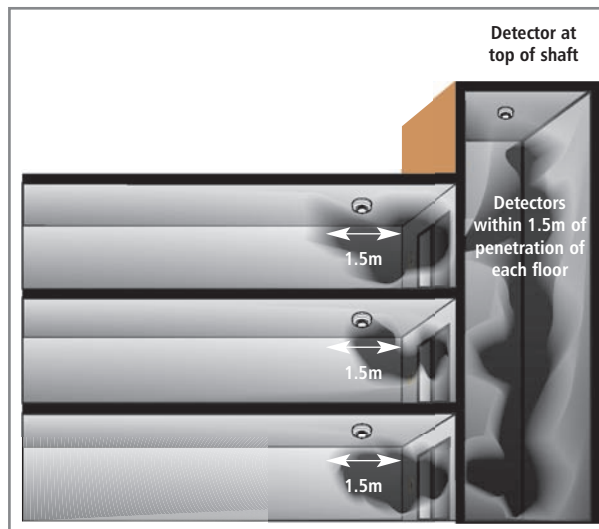
Fire detectors should be mounted at least 500mm away from walls or ceiling obstructions greater than 250mm deep and at least twice the depth of obstructions less than 250mm deep. They should also be mounted at least 1m away from any forced air inlet. Where the obstruction is greater than 10% of the height of an area it should be considered as a wall. Similarly a floor mounted obstruction (such as racking) should be considered a wall if it comes to within 300mm of the height of the detector.



For obstructions of less than 250mm Y should be at least  $2 \times Z$

### 7.8 Lift Shafts

Where detection is required in vertical shafts, such as stairwells, a detector should be mounted at the top of the shaft and within 1.5m at each level.



Typical detector positioning for L2 coverage





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## 7.9 Beam Detectors

Beam detectors provide a cost effective method of covering wide open plan areas, however care should be taken that activities in the space do not obstruct the beam and that the building structure is such that the beam does not 'move' or false operation may result.

If optical beam detectors are mounted within 600mm of the ceiling level, they should be positioned such that no point in a protected space is more than 7.5m from the nearest part of the optical beam. Should the beam detector be mounted more than 600mm below ceiling level then spacings should be altered to 12.5% of the height of the beam detector above the highest likely seat of any fire.

Other than the part of the beam within 500mm of the beam's transmitter or receiver, if any other section of a beam which runs closer than 500mm to any wall partition or other obstruction to the flow of hot gasses, that section of the beam should be discounted from providing protection.

Where optical beam detectors are mounted in the apex of pitched roofs then the same enhanced spacings can be applied as for point smoke detectors (see above)

The area covered by a single optical beam detector should not exceed that of a single detection zone.

## 7.10 Aspirating Systems

Aspirating systems should be specified where protection is required in areas such as cold stores or areas where a very fast response to fire is needed, and whilst each sense point can be considered a smoke detector, special training is needed to design such systems - particularly as they are normally required to cover special risks. Other specialist detectors can be connected to Cooper Lighting and Security systems via interfaces where there is a specific requirement, such as flame detectors or equipment in areas requiring an intrinsically safe installation.

## 7.11 Selection of Manual Callpoints

The selection of manual call points is somewhat simpler. Surface or flush types are selected depending on the environment and whether the fire system is being installed into an existing building (where surface call points are generally easier to install). IP65 types should be specified where there is risk of moisture ingress, for example in external locations. Standard call points use a frangible glass element which is designed to break under light pressure triggering the call point into an alarm condition.

The glass element is covered with a thick plastic film to protect the operator against broken glass, however plastic resettable elements and protective flaps can be used where there is the risk of unwanted operation or in food preparation areas. Where hinged covers are used these should be recorded as a design variation. Call points can be supplied with LED indicators mounted onto the front face to simplify the location of an operated call point.

### 7.12 Positioning of Manual Callpoints

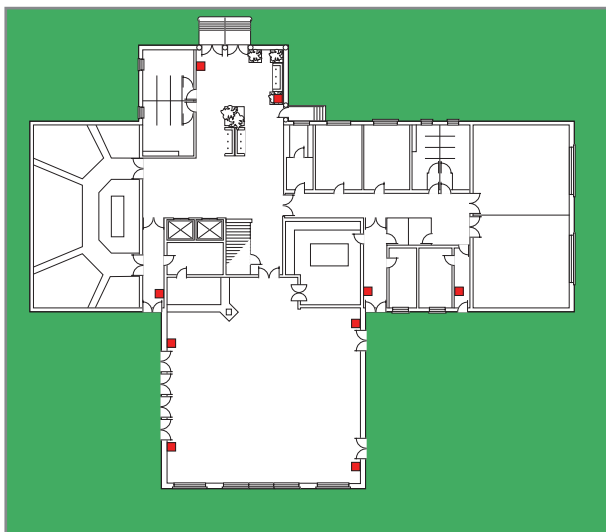
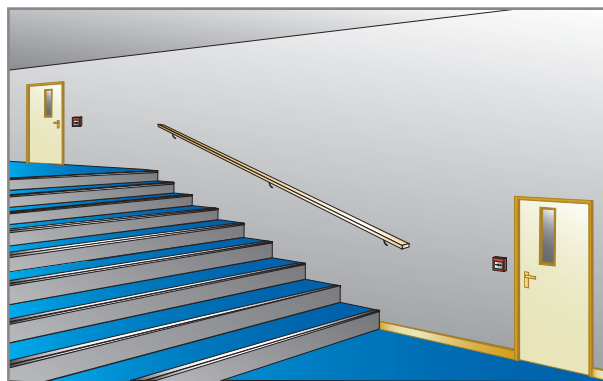
Manual call points should be located on escape routes, at all exits to free air and at all exits from each level of multi-storey buildings.

For general applications, call points should be located such that nobody need to travel more than 45m to reach the nearest call point. This distance is based on measuring the actual route that would be travelled. If at the design stage the actual layout is unknown then a straight-line distance of 30m should be used as a design guide and the 45m limit verified after fit out is complete.

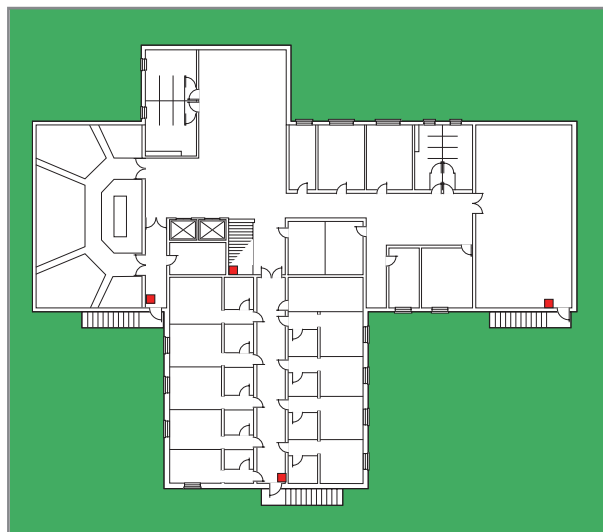
Call points should be located near to specific hazards (e.g. flammable liquid store) and at 1.4m (+/- 0.2m) from the floor in well lit easily accessible positions. Lower mounting heights might be needed to accommodate building users in wheel chairs.

The figures of 45m and 30m above should be reduced to 25m and 16m respectively if either a significant proportion of building users have limited mobility and it can reasonably be assumed that one of these occupants will be likely to be the first person to operate the alarm or if the nature of equipment or activity in an area gives a high likelihood of rapid fire development.

The method of operation of call points should be the same throughout the building - all Cooper Lighting and Security call points meet this requirement, whether IP65 or standard types.



Typical building layout showing positioning of callpoints

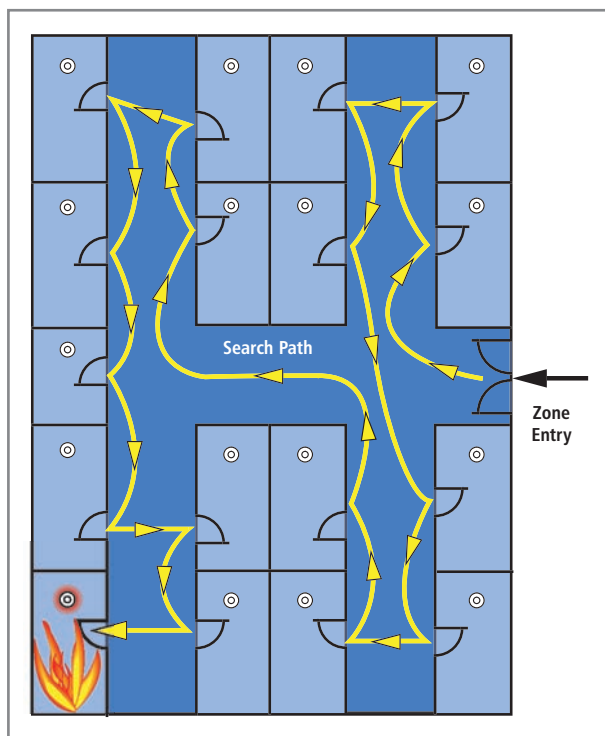


Typical building layout showing positioning of callpoints

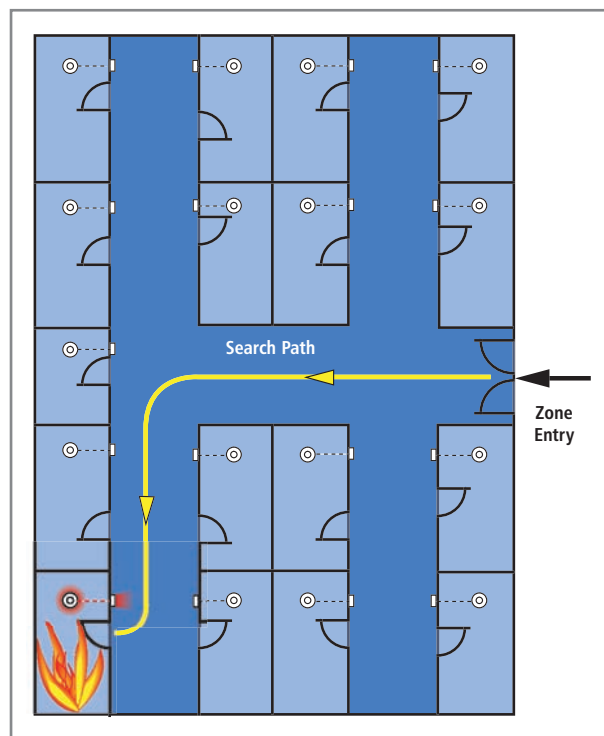
# FIRE SYSTEM DESIGN GUIDE

## 7.13 Remote indicators

Remote indicators should be used in areas where the detector mounting position is such that the detector is not easily viewed, for example in ceiling voids. Remote indicators can also be used to dramatically reduce search distances where detectors are mounted inside rooms, such as in hotels, thus simplifying system zoning and reducing the time taken to locate the source of an alarm.



Without remote indication



With remote indication

### 7.14 Alarm Devices

Alarm devices fall into two types, audible and visual. The audible types are most common, with a variety of types being available from bells to all kinds of different electronic sounders including those containing pre-recorded spoken messages. The choice of device is dependant on local preference, legal requirement and the need to have a tone distinct from all other building audible alarms.

Speech alarms or links to PA systems overcome some of the complacent responses to warning tones and can be used to good effect when carrying out regular fire tests in buildings where there are many people unfamiliar with the regular routines - such as hotels. Finally visual alarms are to be used where the hard of hearing may be occupying a building or where the ambient noise is such (above 90dBA) that audible warning may not be heard, where hearing protectors are in use or where the sounder levels would need to be so high that they might impair the hearing of the building occupant.

BS5839-1 requires that Alarm Circuits should be arranged such that in the event of a single fault at least one sounder operates within the vicinity of the control equipment; or in the case of certain buildings open to large numbers of the general public, a single fault only partially reduces the alarm level. This is met by loop-powered devices or by the use of multiple alarm lines for conventional systems, interleaved throughout the relevant area or by use of at least two zones for Bi wire systems (single zone Bi wire panels have a built-in sounder incorporated within the control panel).

Sound levels should generally be 65dBA or 5dBA above persistent background noise levels. This may be reduced to 60dBA in rooms smaller than 60m<sup>2</sup>, in stairwells or in specific limited points of the building. Most sounders have adjustable output levels, which allows a balance between meeting the requirements of the standard and providing a sensible level of audible comfort.

| Distance from Source (m) | Reduction in DB(A) |
|--------------------------|--------------------|
| 1                        | 0                  |
| 2                        | 6                  |
| 3                        | 9.2                |
| 4                        | 12                 |
| 5                        | 13.9               |
| 6                        | 15.5               |
| 7                        | 16.9               |
| 8                        | 18                 |
| 9                        | 19                 |
| 10                       | 20                 |
| 11                       | 20.8               |
| 12                       | 21.5               |
| 13                       | 22.2               |
| 14                       | 22.9               |
| 15                       | 23.5               |
| 16                       | 24                 |
| 17                       | 24.6               |
| 18                       | 25.1               |
| 19                       | 25.5               |
| 20                       | 26                 |

Generally more low output sounders are better than few high output sounders in this respect.

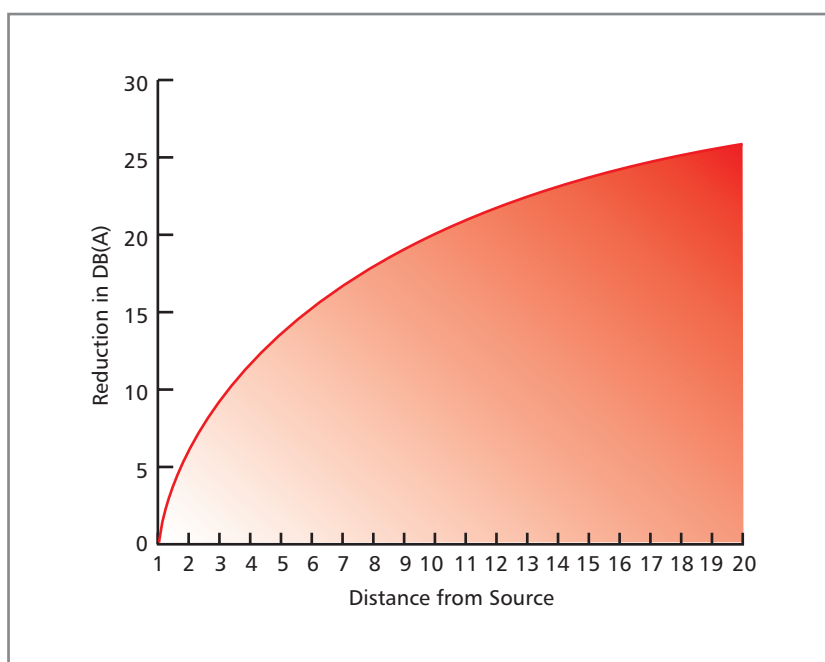
In addition to these general requirements the following specific requirements should also be noted:

- A level of at least 75dBA at the bedhead is required to wake sleeping occupants
- At least one sounder is required per fire compartment
- All of the sounders utilised in a building should emit a similar noise

When considering the number and position of sounders the following should be considered:

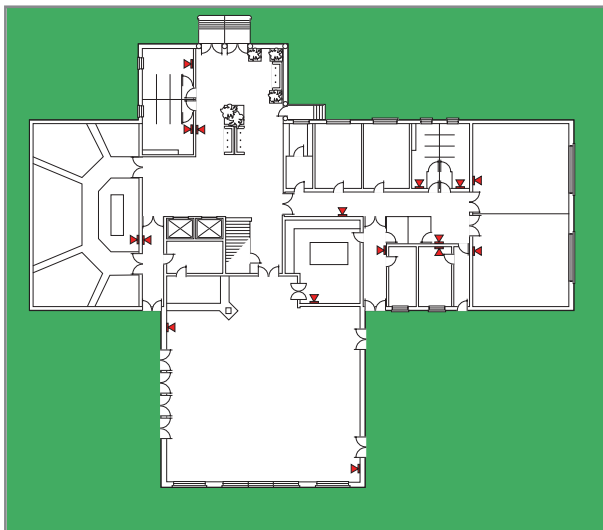
- A loss of at least 20 to 30dBA should be allowed for sound going through doors
- Where two identical sounders are in one location the level increases by only 3dBA
- The sound pressure level drops with distance according to the graph below
- It is necessary to consider cable loading requirements when designing sounder circuits. Volt drop should be limited to less than 10% of nominal voltage
- It is recommended to always err on the side of caution when selecting sounders and their locations as it is far simpler to reduce the volume setting of a sounder where appropriate than to retrofit additional sounders should the initial levels be inadequate

Sounder output levels are normally quoted in dB(a) at 1m, the graph below can be used to calculate effect on sound level at other distances in free air. In addition allowances have to be made for obstructions such as doors, the absorption of sound by furnishings the directional nature of the sounder, mounting position and location of the sounder etc.

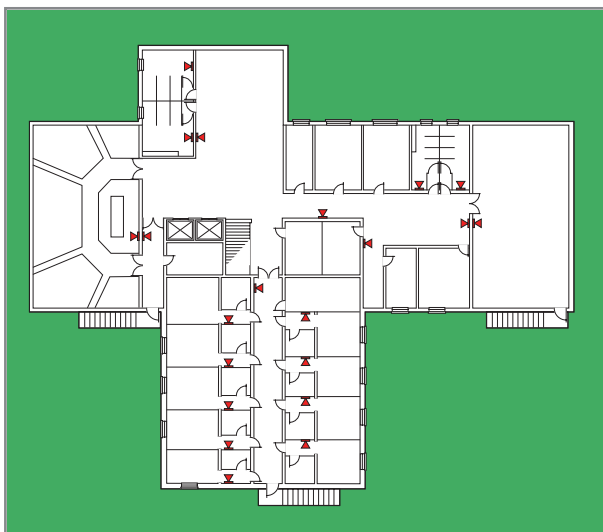


Effect of distance on sound level

# FIRE SYSTEM DESIGN GUIDE



Typical sounder positioning based on sounder with 105dB(a)



Typical sounder positioning based on sounder with 105dB(a)

## 7.15 Fire Protection Equipment

Cooper Lighting and Security provide a range of door holders, interfaces and relays that can be used to control the operation of smoke vents, hatches, ventilation systems, lifts etc. It is recommended that reference is made to the individual product pages of this catalogue or to our technical sales department who will be able to advise on the best type for a particular application.

## 7.16 Alarm Routing Equipment

Alarm output relays are available to connect to alarm routing equipment. The selection of types of routing equipment will depend on the requirements of the selected alarm receiving centre.

## 7.17 Interfaces

The product pages of this catalogue list the range of interfaces that are available, most relate to analogue systems and are designed for specific applications, such as interfacing an analogue panel to a conventional zone of detectors, providing an interface to a shop etc. Conventional systems can interface directly to volt free contacts by using suitable resistors (for monitoring sprinkler flow switches for example) and are provided with relay outputs in the panels to connect to fire and fault routing equipment, fire protection equipment etc.

By definition an interface bridges the gap between two pieces of equipment or two systems, consequently it is essential to consider the requirements of both sides of the interface both from a loading point of view and with regard to functionality and typical fault scenarios.

The main area of caution is to ensure that the voltage rating of the equipment and interface are compatible. For example, 24V relay contacts should not be used to switch mains voltage, even if they appear to work and it is best to provide isolation between systems (such as protection and alarm systems) so that there is no risk of electrical interference causing false alarms.

# FIRE SYSTEM DESIGN GUIDE

## 8.0 DESIGN REVIEW TO MINIMISE FALSE ALARM POTENTIAL

False alarms have the potential to cause substantial disruption to the smooth running of a business and in addition place a tremendous burden on fire service resources.

Regular false alarms can cause building users to disregard alarm signals leading to incorrect actions in the event of a real fire situation. False alarms can broadly be divided into four categories,

- Unwanted alarms
- Equipment false alarms
- Malicious false alarms
- False alarms with good intent

Unwanted alarms are those that are caused by a combination of factors such as environmental conditions, fire like phenomena such as steam, aerosol spray or dust triggering smoke detectors or by inappropriate action by people in the building such as smoking in areas protected by smoke detectors.

The following is designed to assist with selection of equipment to avoid common potential unwanted alarm conditions, BS5839 gives comprehensive guidance on the subject and should be consulted for in depth guidance.

| Area                                                            |                                                                                                                                                        |
|-----------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------|
| Kitchens                                                        | Smoke detectors should never be used                                                                                                                   |
| Areas close to kitchens                                         | Avoid rate of rise heat detectors<br>Avoid smoke detectors if possible<br>Do not install ionisation smoke detectors<br>Consider photo thermal detector |
| Rooms in which toasters are used                                | Avoid smoke detectors if possible<br>Do not install ionisation smoke detectors<br>Consider photo thermal detector                                      |
| Rooms in which people smoke                                     | Avoid smoke detectors if possible<br>Do not install optical smoke detectors<br>Consider photo thermal detector                                         |
| Bathrooms shower rooms and areas where steam occurs             | Avoid smoke detectors if possible<br>Do not install optical smoke detectors<br>Consider photo thermal detector                                         |
| Areas with high dust concentrations                             | Avoid smoke detectors if possible<br>Do not install optical smoke detectors<br>Consider photo thermal detector                                         |
| Areas where the sensing element is subject to high air velocity | Do not install ionisation smoke detectors                                                                                                              |
| Areas in which engine exhaust fumes occur                       | Avoid smoke detectors if possible<br>Do not install ionisation smoke detectors<br>Do not install beam detectors<br>Consider photo thermal detector     |
| Areas close to openable windows                                 | Avoid smoke detectors if possible<br>Do not install ionisation smoke detectors                                                                         |

Photo thermal detectors analyse both change in temperature as well as density of smoke or smoke like phenomena. This can considerably reduce the potential for false alarms. In addition with analogue systems it is possible to configure the detector to operate in heat only mode at specific times when smoke or smoke like phenomena is likely to be present and then to revert to combined smoke and heat detection when the presence of smoke is no longer expected.

## 9.0 CABLES

BS5839-1:2002 introduced more onerous requirements for the types of cables used in fire detection and alarm systems. Fireproof cables should now be used for all parts of the system and enhanced fire resistance cables should be used where there is a requirement to ensure cable integrity over a longer period of time. For example when connecting to alarm sounders or where the connection between sub-panels provides any part of the alarm signal path.

Fire alarm cables should be segregated from the cables of other systems; they should be clearly marked, preferably coloured red and should be routed through parts of the building that provide minimum risk. This latter point is particularly relevant where the use of the building is being changed - for example if a fuel store is being moved.

## 10.0 MAINTENANCE

Regular testing and inspection of the fire alarm system is essential to ensure that it is operating correctly. Many of the functions of the system are monitored but it will still require an inspection of the panel by the responsible person to see the fault indication and all such events should be entered into the system log together with the implementation of an action plan to investigate the reason for the fault and a repair/correction program.

The Cooper Lighting and Security service division is able to provide this function. The advantage of making use of this facility is that the service department will have ready access to all spares and to information relating to possible design changes or specification enhancements that invariably happen over time. BS5839-1 recommends the following minimum regular tests and inspections:

**Daily** - Check to see if the system is indicating fault and that any corrective actions have taken place.

**Weekly** - Test the system by operating a manual call point (different one each week).

**Periodic Inspection** - Subject to risk assessment, should not exceed 6 months between visits. Check the system log and ensure that corrective actions have taken place. Visually inspect all items of equipment, to ensure that the system is not obstructed or rendered inappropriate by change of use. Check for any false alarms, compare to nationally accepted levels and take appropriate action if unacceptable. Test the system on standby power to ensure that the battery is functioning correctly. Check all outputs for correct operation. Check all controls and indicators. Check remote signalling equipment. Additionally any other special checks - for example beam detectors for correct alignment.

**Over 12 month period** - Carried out over 2 or more visits.

In addition to the periodic inspection: Test all manual call points and fire detectors for correct operation. Inspect the analogue detector levels to ensure that they are within correct levels. Check all alarm devices for correct operation. Visually inspect all accessible cable fixings. Confirm the cause and effect programming is correct and up to date.

## 11.0 SYSTEM EXTENSIONS

An extension to a fire alarm system should be planned and implemented with the same care and consideration that was given to the original system. There is always a risk that small extensions may affect the integrity of the whole system. Special care is needed if a different manufacturer is chosen for the extension to ensure that there is compatibility between the old and new equipment and to ensure that system loading constraints are met.



# IP RATINGS

The International Protection code, sometimes called the Ingress Protection code, classifies the protection given by an enclosure against the touching of live parts, contact with moving parts and protection against the ingress of foreign solid bodies. It additionally specifies protection against the harmful ingress of moisture or liquids. Two digits are used to describe its protection rating, called the IP code.

| First Digit - Protection against solid objects                           |   | Second Digit - Protection against liquids                                     |
|--------------------------------------------------------------------------|---|-------------------------------------------------------------------------------|
| No protection                                                            | 0 | No protection                                                                 |
| Protection against large sized bodies e.g. hands                         | 1 | Protection against vertically falling drops of water                          |
| Protection against medium sized bodies e.g. fingers                      | 2 | Protection against drops of water up to 15° from the vertical (Drip proof)    |
| Protection against small bodies, 2.5mm dia. or greater e.g. tools, wires | 3 | Protection against rain falling up to 60° from the vertical (Rain proof)      |
| Protection against very small bodies, 1mm dia. or greater                | 4 | Protection against splashed water from any angle (Splash proof)               |
| Protection against harmful deposits of dust (Dust proof)                 | 5 | Protection against jets of water from any angle (Jet proof)                   |
| Complete protection against deposits of dust (Dust tight)                | 6 | Protection against water from heavy seas e.g. water tight for marine deck use |
|                                                                          | 7 | Protected against immersion for a defined period                              |
|                                                                          | 8 | Protected against immersion for an indefinite period                          |

Example: IP65 is dust tight and jet proof

# GLOSSARY OF TERMS

**Addressable system** is a system in which signals from detectors and call points are individually identified at the control panel and often where alarm devices are individually addressed.

**Alarm of fire** is a warning of outbreak of fire, originated by a person or by an automatic device.

**Alarm receiving centre** is a permanently manned centre, usually provided by a commercial organisation, the staff of which, upon receipt of a fire signal notify the fire service.

**Analogue system** A fire alarm system where the detectors give variable output signals representing the value of sensed phenomena.

**Automatic fire alarm system** is a fire alarm system comprising components for automatically detecting a fire, initiating an alarm of fire and initiating other action as arranged; the system may include manual call points.

**Beam detector** A type of smoke detector which detects smoke by the obscuration of a beam of infra red light passing between a transmitter and receiver.

**Conventional fire alarm** Normally consists of a control panel linked to a number of circuits of smoke, heat detectors and manual call points, and having a number of sounder circuits. Consists of a control panel providing separate circuits per zone for detectors and call points and at least two circuits for alarm devices.

**Critical signal path** All components and interconnections between every fire alarm initiation point (callpoints and detectors) and every fire alarm device.

**Fault warning** is an automatic indication given audibly and/or visibly that a fault exists in a fire alarm system.

**Fire alarm control and indicating equipment** is the hub of a fire alarm system, providing controls and normally a power supply for the system.

**Fire alarm control equipment** is equipment that, on receipt of a fire signal, controls the giving of a fire alarm by one or more of the following:

- (a) Fire alarm sounders
- (b) Fire alarm indicating equipment
- (c) Transmitting a signal to other fire alarm control equipment

**Fire alarm device** is a component of a fire alarm system used to give warning of fire usually a sounder or visual alarm.

**Fire alarm indicating equipment** is the part of a fire alarm system located at protected premises which provides indication of any fire alarm or fault warning received from fire alarm control equipment.

**Fire alarm remote indicating equipment** is the part of an alarm system that indicates the status of the protected premises from where a fire alarm or fault warning is being transmitted.

**Fire alarm sounder** is a component of a fire alarm system for giving an audible warning of fire.

**Fire alarm system** is a system of fixed apparatus for giving an audible and/or visible and/or other perceptible alarm of fire and which may also initiate other action. The term normally incorporates the function of fire detection as well as alarm.

**Fire alarm transmission link** is an electrical circuit for transmitting fire signals and fault warnings from protected premises to a central (fire alarm) station or to a control room.

**Fire Authority** is the Local Government Authority with a statutory responsibility for providing the services of a fire brigade and supporting services in a given geographical area.

**Fire detection system** is a system of fixed apparatus, normally part of an automatic fire alarm system, in which fire detectors, control equipment and indicating equipment are employed for automatically detecting fire and initiating other action as arranged.

**Fire detector** is a device which gives a signal in response to a change in the ambient conditions in the vicinity or within range of the detector, due to a fire.

**Fire point** is a location where fire-fighting equipment is positioned which may also comprise a fire alarm call point and fire instruction notices, the whole being provided and arranged for use by occupants of premises.

**Fire procedure** is collectively and individually all the actions that need to be taken, as part of fire precautions by the occupants of a building or other structure to ensure the avoidance of danger from fire to persons and property.

**Fire protection** is design features, systems or equipment in a building, structure or other fire risk, to reduce danger to persons and property by detecting, extinguishing or containing fires.

**Fire signal** is an alarm of fire originated by an automatic device, given audibly and/or visibly.

**Heat detector** is a form of fire detector that responds to an increase in temperature.

**Ionisation smoke detector** is a smoke detector that responds when smoke, having entered the detector, causes a change in ionisation currents within the detector.

**Lantern Light** A construction standing above the surface of a roof designed to provide light to the space below.

**Manual fire alarm call point** is a device for the manual instigation of a fire alarm condition.

**Manual fire alarm system** is a fire alarm system without automatic detectors, in which the alarm system is initiated manually.

**Mimic diagram** is a topographic representation of the protected premises carrying indicators for each sub division so that the indicators of the fire alarm system can be rapidly related to the layout of the premises.

**Phased evacuation** System of evacuation in which different parts of the building are evacuated in a controlled sequence rather than all at once.

**Photoelectric smoke detector** is a form of fire detector having a photoelectric cell which responds when light is absorbed or scattered by smoke particles.

**Point fire detector** is a form of fire detector which responds to the phenomenon detected at a fixed point at its location.

**Smoke detector** is a form of fire detector that responds to particulate products of combustion.

**Soft addressing** allows the control panel to assign an address to each device automatically instead of it being done manually.

**Self learn mode** allows a totally unprogrammed system to function immediately power and battery are connected (without the need for device related text). The control panel will interrogate each device and assign an address (soft addressing). Manual zone allocation allows the installer to split the devices into zones.

**Short circuit isolator** Component in an addressable system that is able to isolate a detection loop at both sides of a short circuit, minimising the loss of communication.